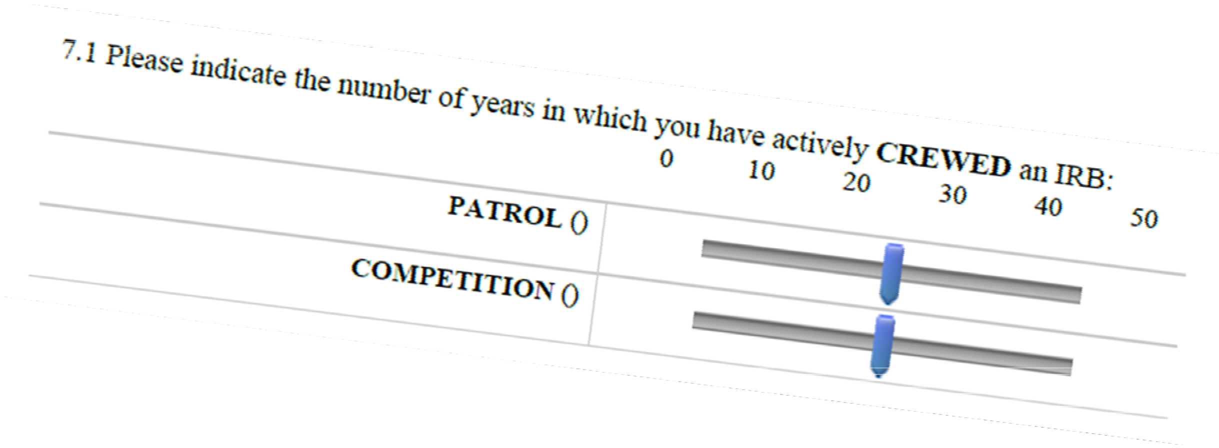
Recreational and competitive surf lifesaving injuries associated with inflatable rescue boats derived from an online survey of members: Technical report #3 to Surf Life Saving New Zealand (SLSNZ)



By research team members for TE HOKAI TAPUWAE – REIMAGINING SPORTS INJURY PREVENTION

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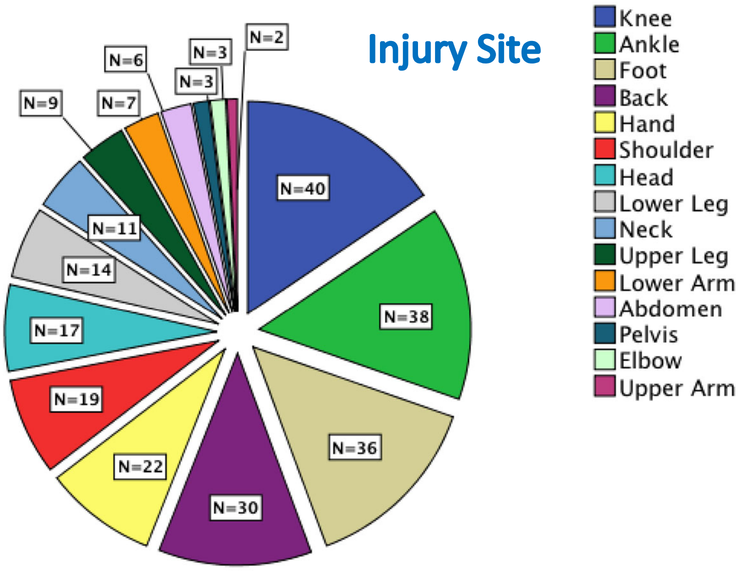
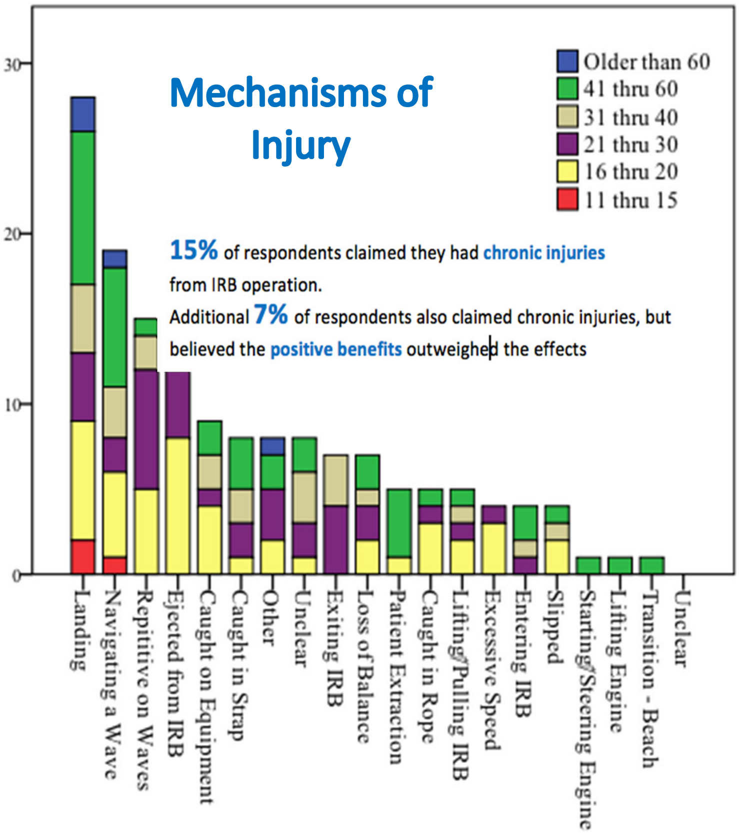
Surf Life Saving New Zealand Members' Questionnaire - Fact Sheet



Total number of respondents reporting at least one sustained injury (out of 196)



15% of respondents claimed they had **chronic injuries** from IRB operation.

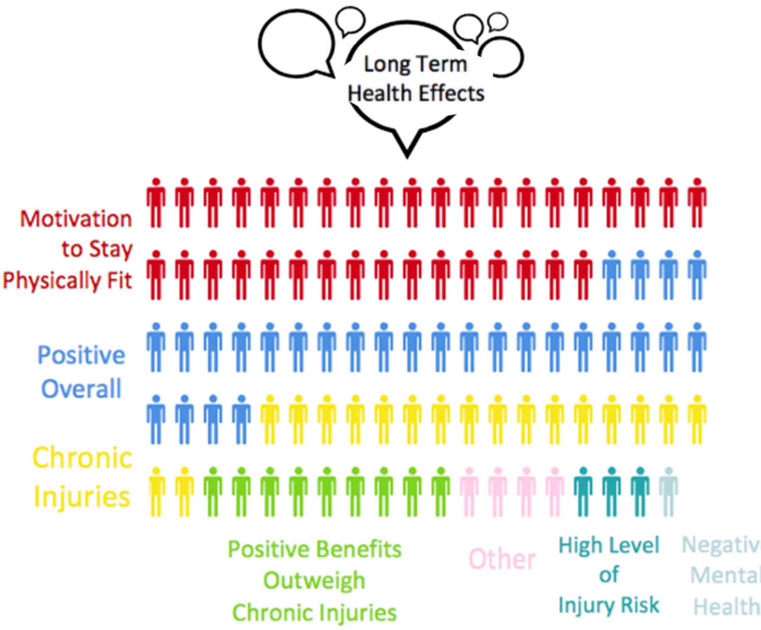
Additional **7%** of respondents also claimed chronic injuries, but believed the **positive benefits** outweighed the effects

Respondent Demographics

♀ 36% N=196 ♂ 63%

Age 34 ±17 yrs

Experience 12 ±12 yrs



Key Findings

- **75% of injured respondents did not report their injuries to SLSNZ; of which 29% were unaware of procedures to report injuries ("occurred during training", "unaware", or "at fault")**
- **Landing in the IRB after being airborne and navigating a wave were the most reported causes of injuries**
- **Chronic injuries were reported by 15% of respondents as a long term health effect of surf lifesaving participation**

Diewald S.N., Hume P.A. et al. (2019). Recreational and competitive surf lifesaving injuries associated with inflatable rescue boats derived from an online survey of members: Technical report #3 to Surf Life Saving New Zealand (SLSNZ).

ABSTRACT

Background: Due to their speed and manoeuvrability in often adverse sea conditions, inflatable rescue boats (IRB) were thought to cause injury to the crew members by Surf Life Saving New Zealand (SLSNZ).

Purpose: To use a questionnaire to quantify risk factors, aetiologies, and mechanisms of IRB-related injury associated with surf lifesaving activities in order to prescribe injury prevention strategies.

Methods: An on-line survey for SLSNZ members who completed a self-reported retrospective questionnaire. The "Sequence of Injury Prevention" approach proposed by van Mechelen, Hlobil [1] was applied to the questionnaire findings.

Results: Of 259 questionnaire respondents, 196 were included in the analysis (124 males: 39.1 ±17.1 years; 70 females: 24.9 ±11.9 years). Younger females experienced significantly more patrol injuries than older males. The most frequently injured body sites were the lower back (15.3% of respondents) and ankle (19.4% of respondents). Sprains and strains were the most reported injury types. Aetiology of injury was established as landing in the IRB for 14.8% of respondents. Chronic injury symptoms were reported by 15.6% of respondents.

Discussion: Utilisation of IRBs during surf lifesaving has a risk of injury to the lower extremities and back, particularly in younger females. Results are most likely an underestimate due to low respondent rates. Future research should consider lower extremity and back strength intervention strategies to help prevent IRB-related acute and chronic injuries.

Conclusion: Sprains and strains were the most common types of injuries for the lower extremity and back. Landing activities were most frequently reported as causing IRB-related injuries. Chronic injuries were reported which may impact long-term outcomes from surf lifesaving participation.

Recommendations:

1. Current IRB crew member guidelines and strength requirements should be considered in order to assure crew members are able to stay inside the IRB and withstand the loads experienced during operation.
2. Preventative strategies such as age- and gender- specific strength training, warm-up protocols, and equipment changes should be implemented and investigated to determine effectiveness in reducing the occurrence of acute and chronic soft tissue injuries.
3. The physical fitness level of surf life savers in New Zealand should be assessed after developing a surf lifesaver task relevant fitness battery.

INTRODUCTION

Swimming and surfing is an integral part of daily life in New Zealand, with over 14,000 kilometres of coast line extending across two major oceans [2, 3]. Surf Life Saving New Zealand (SLSNZ), is responsible for coordination of all surf lifesaving activities taking place at clubs throughout New Zealand. Responsibilities of SLSNZ include the oversight of lifeguard certifications, equipment standards, and member training.

Surf life savers play an important role in keeping the public safe, and as of recently, have come to rely less on traditional non-powered rescue aids such as life rings and more heavily on powered watercrafts; such as the inflatable rescue boat (IRB) to complete open water rescues. Due to their speed and manoeuvrability, IRBs are ideal for beach patrol and surveillance. An IRB consists of two rigid inflatable pontoons supported by a removable fibreglass laminate floor, fitted with an outboard motor and additional crewing equipment (e.g. foot straps, ropes, etc.). New Zealand surf life savers utilise IRBs in over 50% of all rescues per year [4].

The operation of an IRB typically involves two lifeguards; a driver in the stern and a crew member at the bow, racing through the surf simulating or performing a rescue. The crew member is responsible for keeping the IRB balanced through the surf by utilising their body weight and additional equipment such as bow ropes, foot straps … to stay safely inside the boat. The driver is responsible for navigating the IRB through the surf as efficiently as possible while ensuring the crews' safety. Surf life savers participate in regular training to prepare for IRB operation during both patrol and competition.

According to SLSNZ internal injury reports, increased use of IRBs in New Zealand may have resulted in an increase in injury incidents [5-9]. The repetitive nature of IRB operation may increase the incidence of acute and chronic injuries, thus negatively impacting the health of surf life savers. Workers' compensation databases (e.g. OSHA, WorkSafe) were analysed in Australia [10] and the United States [11] to assess 'surf' and 'lifeguard' injuries. Australian epidemiological studies from 1989 – 2011 showed an increased risk of injury while operating an IRB compared to other surf lifesaving formats [10, 12, 13]; the incidence rates of IRB surf lifesaving injuries were reported as between 1.2% to 4.1% in Australia [10, 14], with high incidences of lower limb injuries [10, 15]. The actual incidence and cost of surf lifesaving injuries in New Zealand remains unknown. Soft-tissue injuries were the most common, specifically at the ankle joint, followed by total body fractures [10, 13, 16]. Conflicting findings regarding gender- and age- specific risk factors exist in the literature. However, there was a greater proportion of injury on the right side of the body and occurring mostly to the crew member [10, 16].

Crew member technique and training are potential risk factors of injury [17]. Crew members are positioned on the right (starboard) side of the pontoon, and required to lean and move to balance the boat while navigating through the surf [4]. The mechanisms of lower limb injuries may be influenced by the crew members' foot straps [16, 18]. Foot strap configuration (stance angle, width, and direction) place varying biomechanical limitations on the crew member during operation [17].

Despite foot straps potential contribution to injury, the foot straps play a significant role in the safety of the crew member by decreasing the likelihood of ejection from the IRB. Although previously suspected as a direct cause of lower limb injury [16], the simulated removal of the right foot strap showed no signs of reduced dorsiflexion [17], a recognised risk factor of ankle sprain injuries [19-22]. Nevertheless, the removal of the right foot strap was mandated in New Zealand in 2018 (recommended in 2010 and 2014) [23]. The effect of removing the right foot strap on crew stability and injury risk remains unknown [18, 23].

Due to the varying conditions and demands of the open ocean, and the lack of IRB-specific studies, other water-based board sports (wakeboarding, kitesurfing, and traditional surfing) and associated injuries and mechanisms were reviewed, revealing significant injuries occurring to the lower extremities after landing aerial movements [24-29]. The lower limbs may be unable to handle the excessive dynamic loads during landing, particularly when in a hip and knees flexed position. Increases in general lower extremity strength may help improve the ability to handle the landings [27, 30, 31].

Jackson et al. (2017) distributed a survey to California ocean lifeguards to describe retrospective musculoskeletal injuries occurring whilst lifeguarding and to identify possible risk factors. Of the respondents, 61% (1410 in total) experienced an injury while volunteering. Age, years of experience, and employment status were significantly associated with injury occurrence. Knee, lower leg/ankle, and foot injuries accounted for over 50% total injuries reported [15]. Presently, injury data for ocean lifeguards is scarce, therefore accurate estimation of the prevalence of musculoskeletal injuries in this population is limited.

The aim of this study was to determine the extent and nature of the injuries experienced by surf life savers while operating IRBs in New Zealand. A retrospective questionnaire, based on an extensive literature review, was distributed to *SLSNZ* members to provide a picture of IRB-related injuries and their long-term effects on surf lifesaving participation. A "sequence of injury prevention" approach proposed by van Mechelen, Hlobil [1] was utilised to identify risk factors, aetiologies, and mechanisms of injury in order to prescribe injury prevention strategies. Based on previous reports, it was hypothesized that gender, age, and experience would be significantly associated with occurrence of lower extremity injuries. Furthermore, directed strength interventions were expected to be an effective injury reduction strategy.

METHODS

Ethical Consent

Ethical consent was obtained from the Auckland University of Technology (*AUT*) Ethics Committee (#18380) and Loughborough University Ethics Committee (#R18-P233).

Participants/Respondents

Active and former surf life savers in New Zealand were invited to respond to the survey. Potential participants were informed of the questionnaire via advertisements posted in the SLSNZ monthly newsletter and Facebook page.

Data Collection

The questionnaire administered in this study was developed using a pilot study. The final questionnaire consisted of 100 questions and was completed online via Qualtrics (Qualtrics, Provo, UT). The questionnaire was accessible to participants for 92 days from 11 November 2018 to 11 February 2019. The questionnaire was comprised of five sections. Section 1 (4 questions) encompassed member demographics. Section 2 (14 questions) contained questions surrounding respondents' surf lifesaving patrolling experience; including, certification details, general lifeguard experience, and IRB-specific experience. Respondents were asked to identify year(s) of certification(s), active experience, and position (crew or driver) and format preferences (type of competition). Section 3 (5 questions) contained competition-specific questions similar to Section 2. Related follow-up questions were skipped if negative answers were given. Section 4 (69 questions) encompassed patrol and competition injuries. Respondents were initially prompted to identify if they had ever experienced an injury[1] while patrolling, competing, and/or training for *SLSNZ*. Respondents were asked to document all injuries incurred throughout the duration of their surf lifesaving career. If positive answers were given, members were asked to complete an injury table; identifying number of incidences by injury site and type. For each reported injury, there were questions regarding how, when, and whether the injury was IRB-related. Respondents were then asked to specify how many of their injuries they had reported to *SLSNZ* (all, some, or none), give explanations as to why or why not, and comment on the long-term health outcomes of their surf lifesaving participation as a patrol member and/or competitor. Finally, Section 5 (2 questions) prompted respondents to provide any additional feedback (e.g. rule changes, health outcomes).

Data Analysis

Injury frequencies were classified as either members whom entered a "single" injury (1) or "multiple" injuries (2 or more). Frequencies entered by respondents in text form (i.e. "a lot", "many", etc.) were categorised together as "multiple". Any additional text in the injury table was not included in the analysis. All other free text questions were analysed and categorised into similar sub-groups of answers, as defined by the author. Injury mechanisms were analysed from free text for IRB-related injuries only.

In order to draw a clear boundary between beginner and experienced surf life savers, three groups were defined based on self-reported years of active experience: beginner (less than six active years volunteering and/or competing for surf lifesaving), intermediate (between six and twelve years volunteering and/or competing for surf lifesaving), and experienced (greater than twelve years actively volunteering and/or competing for surf lifesaving). If no active

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[1] Injury was defined as a physical problem that (i) required assessment and/or treatment by a health professional, (ii) caused the member to miss at least one surf lifesaving competition or patrol event, or (iii) caused the member to miss at least two training sessions. Concussion was defined as an injury resulting from a blow to the head that caused an alteration in mental status and one or more of the following symptoms: headache, nausea, vomiting, dizziness/balance problems, fatigue, trouble sleeping, drowsiness, sensitivity to light or noise, blurred vision, difficulty remembering, and difficulty concentrating.

experience was indicated, respondents were not included in the analysis (n = 3). Questionnaires less than 50% completed were also excluded from the analysis (n = 60).

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics (IBM Corp. Released 2016. IBM SPSS Statistics for Macintosh 24.0. Armonk, NY: IBM Corp). Specific injury types and locations are presented as absolute numbers and percentages for all members, separated by gender and experience level. Patrol and competition injury frequencies were combined for analysis. To assess differences between genders, age groups, and experience levels, risk relationships were analysed using chi-squared tests for independence ($p<0.05$), and 95% CI were constructed, where appropriate. Age groups were defined by SLSNZ in order to compare with SLSNZ Injury Report Database.

RESULTS

Participant demographics

A total of 259 respondents took part in the survey. After exclusion criteria were applied, 196 respondents (age: 34.0 ±16.8 years; height: 175.7 ±13.3 cm; experience: 12.4 ±12.0 years) remained for analysis. See Table 1 for a breakdown of male and females by age and experience.

The respondent average progress was 97.6 ±8.7% with a completion time of 22.95 ±89.57 minutes. Lifeguard year of certification ranged from 1958 (1/196) to 2018 (3/196); 50.5% (99/196) were certified in 2010 or later. Experience levels varied across respondents; 38.8% (76/196) were beginners (males: 41/124, 33.1%; females: 35/70, 50.0%), 25.0% (47/196) were intermediates (males: 25/124, 20.2%; females: 22/70, 31.4%), and 36.2% (71/196) were experienced (males: 58/124, 46.8%; females: 13/70, 18.6%). There was an association between gender and experience level (χ^2=15.3 (2), p=.000). The average age of respondents was 34.0 ±16.8 years (range: 14 – 88 years). Respondents whom competed in at least one surf lifesaving competition included 78.2% (97/124) of males and 72.9% (51/70) of females. Overall, 92/194[2] (47.4%; males: 66/124, 53.2%; females: 26/70, 37.1%) experienced an injury during patrol and/or training for patrol. A total of 53/191[3] respondents experienced an injury during competition and/or training for competition (27.6%; males: 29/122, 23.4%; females: 24/69, 34.3%).

IRB-*related*

IRBs were driven by 80.6% (158/196) of respondents (males: 113/124, 91.1%; females: 43/70, 61.4%) and crewed by 95.9% (188/196) (males: 121/124, 97.6%; females: 65/70, 92.9%). Of the respondents whom indicated they had driven an IRB, 15/158 (9.5%) were not certified to do so; 9/15 (60.0%) were under the age of 21. The average patrol and competition driving experience were 9.4 ±10.1 years and 2.5 ±4.8 years, respectively. The average patrol and competition crewing experience were 9.5 ±9.7 years and 1.9 ±4.1 years, respectively (males: 11.8 ±10.9 years; females 5.1 ±4.9 years). Females were more likely than males to sustain an injury while on patrol (χ^2=32.1 (2), p=.000), and spent most of their patrol and competition IRB experience crewing (86.7%). Preferences of IRB position for patrol and competition varied between genders (

[2] Not all respondents completed every question (e.g. 2/196 respondents did not answer the patrol injury questions)

[3] Not all respondents completed every question (e.g. 5/196 respondents did not answer the competition injury questions)

Table 2).

Table 1 - SLSNZ Members' Questionnaire: Study population demographics

	Age[a]														Height		Ethnic Origin													
	Unknown		11 thru 15		16 thru 20		21 thru 30		31 thru 40		41 thru 60		Older than 60		Mean (cm)	Std. Dev (cm)	Unknown		Samoan, Other		NZ Maori		NZ European, Other		NZ European, NZ Maori		NZ European		Other	
	(n)	Total (%)	(n)	Total (%)	(n)	Total (%)	(n)	Total (%)	(n)	Total (%)	(n)	Total (%)	(n)	Total (%)			(n)	Total (%)	(n)	Total (%)	(n)	Total (%)	(n)	Total (%)	(n)	Total (%)	(n)	Total (%)	(n)	Total (%)
Male	0	0.0	3	33.3	23	46.0	19	47.5	19	73.1	46	86.8	14	93.3	181.5	7.2	0	0.0	0	0.0	2	1.0	1	0.5	7	3.6	107	54.6	7[e]	3.6
Female	1	33.3	6	66.7	27	54.0	21	52.5	7	26.9	7	13.2	1	6.7	165.5	15.3	0	0.0	0	0.0	2	1.0	0	0.0	8	4.1	56	28.6	4[f]	2.0
Beginner	1	33.3	9	100	42	84.0	4	10.0	3	11.5	16	30.2	1	6.7	173.8	16.2	0	0.0	0	0.0	2	1.0	0	0.0	4	2.0	62	31.6	8[b]	4.1
Intermediate	2	66.7	0	0.0	8	16.0	26	65.0	5	19.2	7	13.2	1	6.7	173.9	11.9	2	1.0	0	0.0	1	0.5	0	0.0	8	4.1	36	18.4	2[c]	1.0
Experienced	0	0.0	0	0.0	0	0.0	10	25.0	18	69.2	30	56.6	13	86.7	179.1	9.6	0	0.0	0	0.0	1	0.5	1	0.5	3	1.5	65	33.2	1[d]	0.5
Total	**3**	**100**	**9**	**100**	**50**	**100**	**40**	**100**	**26**	**100**	**53**	**100**	**15**	**100**	**175.7**	**13.3**	**0**	**1.0**	**0**	**0.0**	**4**	**2.0**	**1**	**0.5**	**15**	**7.7**	**163**	**83.2**	**11[g]**	**5.6**

Experience Level was determined by years of active experience patrolling and/or competing: beginner (less than six active years volunteering and/or competing for surf lifesaving), intermediate (between six and twelve years volunteering and/or competing for surf lifesaving), and experienced (greater than twelve years actively volunteering and/or competing for surf lifesaving).

a. Age at the time the questionnaire was completed

b. Australian (1), British (1), British/Irish (1), Dutch (1), South African (3)

c. Dutch (1), German (1)

d. British (1)

e. British (2), Dutch (2), German (1), South African (2)

f. Australian (1), British/Irish (1), South African (1)

g. Australian (1), British (2), British/Irish (1), Dutch (2), German (1), "New Zealander" (1), South African (3)

Table 2 - SLSNZ Members' Questionnaire: Preferred position in the IRB *and position in which the majority of* IRB *experience occurred*

			Gender						Lifeguard Experience Level							
			Male		Female		**Total**		Beginner		Intermediate		Experienced		**Total**	
			(n)	(%)	(n)	(%)	**(n)**	**(%)**	(n)	(%)	(n)	(%)	(n)	(%)	**(n)**	**(%)**
Preferred Position in IRB	Patrol	Preferred Driver	73	60.8	21	31.8	**94**	**50.5**	31	42.5	24	53.3	41	58.6	**96**	51.1
		Preferred Crew	12	10.0	31	47.0	**43**	**23.1**	23	31.5	9	20.0	11	15.7	**43**	22.9
		No Preference	35	29.2	14	21.2	**49**	**26.3**	19	26.0	12	26.7	18	25.7	**49**	26.1
		Total	**120**	**100**	**66**	**100**	**186**	**100**	**73**	**100**	**45.0**	**100**	**70.0**	**100**	**188**	**100**
	Competition	Preferred Driver	27	37.5	7	16.7	**34**	**29.8**	8	17.4	9	33.3	18	42.9	**35**	**30.4**
		Preferred Crew	17	23.6	18	42.9	**35**	**30.7**	15	32.6	11	40.7	9	21.4	**35**	**30.4**
		No Preference	28	38.9	17	40.5	**45**	**39.5**	23	50.0	7	25.9	15	35.7	**45**	**39.1**
		Total	**72**	**100**	**42**	**100**	**114**	**100**	**46**	**100**	**27**	**100**	**42**	**100**	**115**	**100**
Majority of IRB Experience	Driving	Patrol ONLY	0	0.0	0	0.0	**0**	**0.0**	0	0.0	0	0.0	0	0.0	**0**	**0.0**
		Competition ONLY	1	3.7	0	0.0	**1**	**2.8**	0	0.0	0	0.0	1	4.3	**1**	**2.8**
		Patrol and Competition	26	96.3	9	100	**35**	**97.2**	5	100	8	100	22	95.7	**35**	**97.2**
		Total	**27**	**100**	**9**	**100**	**36**	**100**	5	100	8	100	23	100	**36**	**100**
	Crewing	Patrol ONLY	0	0.0	0	0.0	**0**	**0.0**	0	0.0	0	0.0	0	0.0	**0**	**0.0**
		Competition ONLY	6	19.4	2	13.3	**8**	**17.4**	4	25.0	2	16.7	3	15.8	**9**	**19.1**
		Patrol and Competition	25	80.6	13	86.7	**38**	**82.6**	12	75.0	10	83.3	16	84.2	**38**	**80.9**
		Total	**31**	**100**	**15**	**100**	**46**	**100**	**16**	**100**	**12**	**100**	**19**	**100**	**47**	**100**

Injury site

Table 3 provides a breakdown of injury by site. The lower extremity was the most reported injury site (84/196, 42.9%) with 45% (32/71) of experienced respondents reporting sustaining a lower extremity injury. The most commonly injured sites were the knee (males: 26/124, 21.0%; females: 14/70, 20.0%), ankle (males: 25/124, 20.2%; females: 13/70, 18.6%), and foot (males: 23/124, 18.5%; females: 13/70, 18.6%) The back was the most injured location outside of the lower extremity (30/196, 15.3%; males: 19/124, 15.3%; females: 11/70, 15.7%). The greatest number of respondents reported repeat ("multiple") injuries at the ankle compared to any other location (16/38[4], 44.7%). The majority of lower-extremity injuries occurred to respondents during patrol and/or training for patrol (single: 55/75[5], 73.3%; multiple: 24/33[6], 55.8%; total: 66/84[7], 78.6%); compared to competition and/or training for competition (single: 24/75, 32.0%; multiple: 11/33, 33.3%; total: 27/84, 32.1%). The exposure to training, patrol and competition was not recorded.

Table 3 - SLSNZ Members' Questionnaire: IRB-*related injury summary of patrol and competition injuries by anatomical site*

		Injuries (n)	Number of Injured Respondents[a]	Injured / Total Respondents (%)[d]
Knee	Total[a]	-	40	20.4
	Single[b]	31	31	15.8
	Multiple[c]	11	10	5.1
Ankle	Total	-	38	19.4
	Single	24	24	12.2
	Multiple	17	16	8.2
Foot	Total	-	36	18.4
	Single	27	27	13.8
	Multiple	13	12	6.1
Lower Leg	Total	-	14	7.1
	Single	10	10	5.1
	Multiple	4	4	2.0
Upper Leg	Total	-	9	4.6
	Single	4	4	2.0
	Multiple	5	5	2.6
Lower Extremity		**-**	**84**	**42.9[d]**
Hand	Total	-	22	11.2
	Single	15	15	7.7
	Multiple	9	8	4.1
Shoulder	Total	-	19	9.7
	Single	14	14	7.1
	Multiple	5	5	2.6
Lower Arm	Total	-	7	3.6
	Single	4	4	2.0
	Multiple	3	3	1.5
Elbow	Total	-	3	1.5

[4] This total (38) represents the total number of respondents sustaining at least one injury to the ankle during patrol, competition, and/or training.

[5] This total (75) represents the total number of respondents sustaining a single injury to the lower-extremity during patrol, competition, and/or training.

[6] This total (33) represents the total number of respondents sustaining two or more of the same injuries (e.g. multiple) during patrol, competition, and/or training.

[7] This total (84) represents the total number of respondents sustaining one or more injury during patrol, competition, and/or training.

		Single	3	3	1.5
		Multiple	0	0	0.0
	Upper Arm	Total	-	2	1.0
		Single	1	1	0.5
		Multiple	1	1	0.5
Upper Extremity			**-**	**44**	**22.4[d]**
	Back	Total	-	30	15.3
		Single	22	22	11.2
		Multiple	8	8	4.1
	Head	Total	-	17	8.7
		Single	14	14	7.1
		Multiple	4	4	2.0
	Neck	Total	-	11	5.6
		Single	8	8	4.1
		Multiple	4	4	2.0
	Abdomen	Total	-	6	3.1
		Single	5	5	2.6
		Multiple	1	1	0.5
	Pelvis	Total	-	3	1.5
		Single	1	1	0.5
		Multiple	2	2	1.0
Other			**-**	**45**	**23.0[d]**

a. Total is equal to the total respondents sustaining either a ‘single’ or ‘multiple’ injury at an anatomical location during patrol, competition, and/or training. If a respondent indicated sustaining an injury at the same anatomical location during both patrol and competition, they are counted only once in this total (removing duplicates).
b. Respondents indicated they only sustained a single injury. Injury incidence is equal to 1.
c. Respondents indicated they sustained more than one injury. Injury incidence is equal to 2 or greater.
d. Percentage (%) of total survey respondents (%=n/196) that sustained a single or multiple injury at the anatomical location during either patrol, competition, and/or training

Injury Type

Table 4 provides a breakdown of injury by injury type. The most respondents reported ‘sprains and strains’ (72/196, 36.7%; males: 48/72, 66.7%; females: 24/72, 33.3%). ‘Sprains and strains’ were also the most reported repeat injuries (multiple: 32/72[8], 58.3%; single: 57/72, 72.2%). Of respondents reporting a ‘sprain or strain’, 58/72 (80.6%) occurred to the lower extremity (males: 39/58, 67.2%; females: 19/58, 32.8%), compared to 31/40 (77.5%) respondents reporting a ‘fracture’ injury (males: 18/40, 45.0%; females: 13/40, 32.5%). Of respondents, 70.8% (51/72) reported at least one ‘sprains and strains’ injury sustained during patrol and/or training for patrol (total: 51/72, 38.9%; males: 38/51, 74.5%; females: 13/51, 25.5%), while 38.9% of respondents reported at least one ‘sprains and strains’ injury occurring during competition and/or training for competition (total: 28/72, 38.9%; males: 14/28, 50.0%; females: 14/28, 50.0%).

Table 4 - SLSNZ Members' Questionnaire: IRB-*related injury summary of patrol and competition injuries by injury type.*

		Injuries (n)	Number of Injured Respondents[a]	Injured Total / Questionnaire Respondents (%)[e]
Sprains and Strains	Total[a]	-	72	36.7
	Single[b]	57	57	29.1
	Multiple[c]	42	32	16.3
Cuts and Bruises	Total	-	42	21.4
	Single	29	29	14.8
	Multiple	21	16	8.2
Fractures	Total	-	40	20.4
	Single	34	34	17.3
	Multiple	8	8	4.1
Other[d]	Total	-	31	15.8
	Single	29	29	14.8
	Multiple	7	6	3.1

Injury defined as "a physical problem that (i) required assessment and/or treatment by a health professional, (ii) caused the member to miss at least one surf lifesaving competition or patrol event, or (iii) caused the member to miss at least two training sessions."

a. Total is equal to the total respondents sustaining either a ‘single’ or ‘multiple’ injury at an anatomical location during patrol, competition, and/or training. If a respondent indicated sustaining an injury at the same anatomical location during both patrol and competition, they are counted only once in this total (removing duplicates).
b. Respondents indicated they only sustained a single injury per anatomical location. Injury incidence is equal to 1.
c. Respondents indicated they sustained more than one injury per anatomical location. Injury incidence is equal to 2 or greater.
d. 'Other' injuries specified: torn meniscus (knee) (1), prolapsed disc (back) (2), disc slip (neck) (1), concussion (4), rotator cuff (shoulder) (1), broken nail (hand) (2)
e. Injured members as a percentage of the total questionnaire respondents (% = n/196)

[8] This total (72) represents the total number of respondents reporting at least one or more ‘sprains and strain’ injury during either patrol, competition, and/or training.

Injury mechanism (*IRB*-related only)

Injury mechanisms were only reported for IRB-related injuries. Mechanisms were only available for one injury incidence (single or multiple) at each location of injury (e.g. mechanism of only ankle sprain, not ankle cut/bruise). Of respondents, 74/196 (37.8%) reported IRB-related injuries during patrol and/or training for patrol; 21/196 (10.7%) reported IRB-related injuries during competition and/or training for competition. The most common mechanism of injury was landing in the IRB after being airborne (patrol: 24/126[9] (19.0%) per 74 respondents; competition: 5/29[10] (17.2%) per 21 respondents). Respondents aged 16 to 20 years reported the most injuries sustained while being ejected from the IRB (8/25[11], 32.0% per 50 respondents), rather than 'landing' (7/25, 28.0% per 50 respondents) (Table 5).

Table 5 - SLSNZ Members' Questionnaire: IRB*-related injury summary of patrol and competition mechanisms of injury.*

	Injured Members (n)	Injured Members / Mechanism Type (%)	Injured Total / Questionnaire Respondents (%)[g]
Caught in Rope	5	22.7	2.6
Caught in Strap	8	36.4	4.1
Caught on Equipment[a]	9	40.9	4.6
Total Caught in IRB **Equipment**	**22**	**100**	**11.2**
Transition - Beach[b]	1	8.3	0.5
Exiting IRB	7	58.3	3.6
Entering IRB	4	33.3	2.0
Total Transition Injuries	**12**	**100**	**6.1**
Lifting Engine	1	7.7	0.5
Lifting/Pulling IRB	6	46.2	3.1
Starting/Steering Engine	1	7.7	0.5
Patient Extraction[c]	5	38.5	2.6
Total Equipment Maneuver Injuries	**13**	**100**	**6.6**
Slipped	4	9.8	2.0
Loss of Balance	8	19.5	4.1
Landing[d]	29	70.7	14.8
Total Floorboard Injuries	**41**	**100**	**20.9**
Navigating a Wave	19	37.3	9.7
Ejected from IRB	13	25.5	6.6
Repetitive on Waves[e]	15	29.4	7.7
Excessive Speed	4	7.8	2.0
Total Open Water Injuries	**51**	**100**	**26.0**
Other	8	-	4.1
Unclear[f]	8	-	4.1

Not all injuries reported were accompanied by a description of injury and the injury mechanism could not be determined. Only IRB-related injuries (as specified by members) were analysed.

[9] The total (126) represent the total patrol injury mechanisms analysed. This may include individual respondents reporting mechanism of injuries at different locations. Therefore, these values are not member counts but rather adjusted injury counts.

[10] The total (29) represents the total competition injury mechanisms analysed. This may include individual respondents reporting mechanism of injuries at different locations. Therefore, these values are not member counts but rather adjusted injury counts.

[11] The total (25) represents the total patrol and competition injury mechanisms analysed for ages 16-20. This may include individual respondents reporting mechanism of injuries at different locations. Therefore, these values are not member counts but rather adjusted injury counts.

a. Other equipment includes metal, side of the pontoon, etc.
b. Injuries involving movement on the beach, prior to or following IRB operation
c. Including injuries to both the IRB crew member and the patient being extracted (if a surf lifesaver)
d. Injuries occurring upon landing after aerial movement while inside the IRB and on water
e. Injuries described as occurring due to the repetitive nature of IRB operation
f. Mechanism of injury was specified, but was unclear
g. Injured members as a percentage of the total survey respondents (n=196)

Reporting rates

Of respondents, only 28.3% (26/92) whom sustained injuries during patrol and/or training for patrol reported all of the injuries to *SLSNZ* (males:18/66, 27.3%; females: 8/26, 30.8%) (*Table 6*). Of respondents whom sustained injuries during competition and/or training for competition, 11.3% (6/53) reported all the injuries to *SLSNZ* (males: 5/29, 17.2%; females: 1/24, 4.2%). The remaining 70.0% (64/92) of respondents did not report any or only some of the injuries sustained during patrol. Half of respondents aged 16 to 20 years did not report any of their injuries (13/26 (50.0%)). 48.1% (13/27) of those whom reported chronic injuries, did not report any of the injuries they sustained to *SLSNZ*. The main reason for not reporting injuries; according to respondents, was the lack of severity of the injuries (22/68[12], 32.4%). 11/68 (16.2%) respondents were unaware of the *SLSNZ* reporting procedures (*Table 7*). Additionally, 9/68 (13.2%) respondents did not report their injuries because they either occurred during training (7/68, 10.3%) or respondents' injuries were due to their own fault (2/68, 2.9%). Of male respondents, 7/38 (18.4%) stated they did not report all their injuries because they were "not worth it"; no female respondents reported this reason.

Table 6 - Surf Life Saving New Zealand Injury Reporting Rates: Injuries sustained during patrol, competition, and/or training reported to SLSNZ

		Gender				Total[a]	
		Male		Female			
		(n)	(%)	(n)	(%)	**(n)**	**(%)**
Patrol OR Training for Patrol	Reported All	18	27.7	8	32.0	26	28.9
	Reported Some	12	18.5	6	24.0	18	20.0
	Reported None	35	53.8	11	44.0	46	51.1
	Total	**65**	**100**	**25**	**100**	**90**	**100**
Competition OR Training for Competition	Reported All	5	26.3	1	5.3	6	15.8
	Reported Some	3	15.8	3	15.8	6	15.8
	Reported None	11	57.9	15	78.9	26	68.4
	Total	**19**	**100**	**19**	**100**	**38**	**100**

a. The total and associated percentages (%) represents the total number of respondents whom answered the question(s) regarding patrol and competition injury reporting

[12] The total (68) represents the cumulative total respondents whom did not report any or only some of their injuries sustained during patrol, competition, and/or training.

Table 7 - Surf Life Saving New Zealand Reporting Rates: Reasons for reporting only some or none of injuries sustained during patrol, competition, and/or training

		Gender				Total[a]	
		Male		Female			
		(n)	(%)	(n)	(%)	**(n)**	**(%)**
Reasons for Not Reporting Injuries (Some or None)	Importance Not Shown by Supervisors	1	2.6	1	3.3	2	2.9
	Not Serious Enough	13	34.2	9	30.0	22	32.4
	Not Worth It	7	18.4	0	0.0	7	10.3
	Occurred During Training	1	2.6	6	20.0	7	10.3
	Symptoms Developed Later	4	10.5	1	3.3	5	7.4
	At Fault	1	2.6	1	3.3	2	2.9
	Unaware of Procedures	3	7.9	8	26.7	11	16.2
	Unwanted Outcomes	1	2.6	0	0.0	1	1.5
	Other	4	10.5	3	10.0	7	10.3
	Unclear	3	7.9	1	3.3	4	5.9
	Total	**38**	**100**	**30**	**100**	**68**	**100**

a. The total and associated percentages (%) represents the total number of respondents whom answered the question(s) regarding patrol and competition injury reporting.

Participation health benefits and additional feedback

Table 8 provides a breakdown of health outcomes of surf lifesaving participation. Out of 196 questionnaires, 85.2% (167/196) of respondents commented on the health costs of surf lifesaving participation (Section 5). Motivation to stay physically fit was reported by 53/167 (31.7%) respondents as a benefit of surf lifesaving participation (males: 32/110[13], 29.1%; females: 21/57[14], 36.8%). 25.1% (42/167) of respondents had overall positive health outcomes from surf lifesaving participation, while 16.2% (27/167) sustained chronic[15] injuries from participation. A further 14/167 (8.3%) respondents commented on chronic injuries but believed the positive benefits outweighed these injuries. The percentage of respondents commenting on chronic injuries increased with experience level (beginner: 7/69, 10.1%; intermediate: 9/41, 22.0%; experienced: 11/58, 19.0%). A lower extremity injury was sustained during patrol, competition, and/or training by 21/27 (77.8%) respondents who commented on chronic injuries.

Additional feedback was provided by 91/196 (46.4%) respondents (male: 69/124, 55.6%; females: 23/70, 32.9%) (

[13] The total (110) represents the total number of males whom answered the health outcomes question

[14] The total (57) represents the total number of females whom answered the health outcomes question

[15] Chronic injuries were not defined in this questionnaire. Rather, if responses included mention of symptoms or injuries that were 'reoccurring', 'ongoing', ‘persistent’ or the like, they were categorised as 'chronic'.

Table 9). A total of 19 respondents disagreed with regulation changes; 15/91 (16.5%) respondents disapproved of recent helmet regulations mandated by SLSNZ in October 2018) (beginner: 2/15, 13.3%; intermediate: 5/15, 33.3%; experienced: 8/15, 53.3%). Both members (2/19) who disagreed with the SLSNZ removal of the right foot strap [23] had sustained a lower extremity injury during patrol, competition, and/or training.

Table 8 - SLSNZ Members' Questionnaire: Responses on long term health benefits of surf lifesaving participation

		Age Range												Total	
		11 thru 15		16 thru 20		21 thru 30		31 thru 40		41 thru 60		Older than 60			
		(n)	Total per Age Range (%)	(n)	Total per Age Range (%)	(n)	Total per Age Range (%)	(n)	Total per Age Range (%)	(n)	Total per Age Range (%)	(n)	Total per Age Range (%)	**(n)**	**Total (%)**
Positive Overall	Unknown	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Male	1	11.1	6	12.0	2	5.0	3	11.5	10	18.9	6	40.0	28	16.8
	Female	3	33.3	2	4.0	5	12.5	2	7.7	2	3.8	0	0.0	14	8.4
	Total	**4**	**44.4**	**8**	**16.0**	**7**	**17.5**	**5**	**19.2**	**12**	**22.6**	**6**	**40.0**	**42**	**25.1**
Motivation to Stay Physically Fit	Unknown	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Male	1	11.1	8	16.0	3	7.5	5	19.2	13	24.5	2	13.3	32	19.2
	Female	2	22.2	10	20.0	2	5.0	3	11.5	3	5.7	1	6.7	21	12.6
	Total	**3**	**33.3**	**18**	**36.0**	**5**	**12.5**	**8**	**30.8**	**16**	**30.2**	**3**	**20.0**	**53**	**31.7**
Sun Damage	Unknown	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Male	0	0.0	1	2.0	2	5.0	1	3.8	1	1.9	0	0.0	5	3.0
	Female	0	0.0	0	0.0	0	0.0	1	3.8	0	0.0	0	0.0	1	0.6
	Total	**0**	**0.0**	**1**	**2.0**	**2**	**5.0**	**2**	**7.7**	**1**	**1.9**	**0**	**0.0**	**6**	**3.6**
Negative Mental Health	Unknown	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Male	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Female	0	0.0	1	2.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6
	Total	**0**	**0.0**	**1**	**2.0**	**0**	**0.0**	**0**	**0.0**	**0**	**0.0**	**0**	**0.0**	**1**	**0.6**
Positive Benefits Outweigh Chronic Injuries	Unknown	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Male	0	0.0	2	4.0	2	5.0	1	3.8	4	7.5	0	0.0	9	5.4
	Female	0	0.0	4	8.0	1	2.5	0	0.0	0	0.0	0	0.0	5	3.0
	Total	**0**	**0.0**	**6**	**12.0**	**3**	**7.5**	**1**	**3.8**	**4**	**7.5**	**0**	**0.0**	**14**	**8.4**
	Unknown	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Male	0	0.0	1	2.0	0	0.0	1	3.8	0	0.0	0	0.0	2	1.2

High Level of Injury Risk	Female	0	0.0	1	2.0	0	0.0	1	3.8	1	1.9	0	0.0	3	1.8
	Total	**0**	**0.0**	**2**	**4.0**	**0**	**0.0**	**2**	**7.7**	**1**	**1.9**	**0**	**0.0**	**5**	**3.0**
Chronic Injuries[a]	Unknown	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Male	0	0.0	0	0.0	5	12.5	2	7.7	9	17.0	2	13.3	18	10.8
	Female	1	11.1	3	6.0	4	10.0	0	0.0	0	0.0	0	0.0	8	4.8
	Total	**1**	**11.1**	**3**	**6.0**	**9**	**22.5**	**2**	**7.7**	**9**	**17.0**	**2**	**13.3**	**26**	**15.6**
Other	Unknown	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Male	1	11.1	1	2.0	0	0.0	1	3.8	1	1.9	1	6.7	5	3.0
	Female	0	0.0	0	0.0	1	2.5	0	0.0	0	0.0	0	0.0	1	0.6
	Total	**1**	**11.1**	**1**	**2.0**	**1**	**2.5**	**1**	**3.8**	**1**	**1.9**	**1**	**6.7**	**6**	**3.6**
None[b]	Unknown	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Male	0	0.0	2	4.0	3	7.5	2	7.7	3	5.7	1	6.7	11	6.6
	Female	0	0.0	2	4.0	0	0.0	0	0.0	1	1.9	0	0.0	3	1.8
	Total	**0**	**0.0**	**4**	**8.0**	**3**	**7.5**	**2**	**7.7**	**4**	**7.5**	**1**	**6.7**	**14**	**8.4**
Total	Unknown	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Male	3	33.3	21	46.0	17	47.5	16	73.1	41	86.8	12	93.3	110	65.9
	Female	6	66.7	23	54.0	13	52.5	7	26.9	7	13.2	1	6.7	57	34.1
	Total	**9**	**100**	**44**	**100**	**30**	**100**	**23**	**100**	**48**	**100**	**13**	**100**	**167**	**100**

Not all questionnaire respondents answered the 'long term health outcomes' question. Percentages of totals are taken as the total number of answering respondents (167/196, 85.2%).

a. Chronic injuries were not defined in this questionnaire. Rather, if responses included mention of symptoms or injuries that were 'reoccurring', 'ongoing', ‘persistent’ or the like, they were categorised as 'chronic'.

b. Respondents identified 'no long-term health costs'.

Table 9 - SLSNZ Members' Questionnaire: Respondents' responses of feedback; categorised

	Age Range													
	11 thru 15		16 thru 20		21 thru 30		31 thru 40		41 thru 60		Older than 60		**Total**	
	(n)	Total per Age Range (%)	(n)	Total per Age Range (%)	(n)	Total per Age Range (%)	(n)	Total per Age Range (%)	(n)	Total per Age Range (%)	(n)	Total per Age Range (%)	**(n)**	**Total (%)**
Disagree with *SLSNZ* Helmet Regulations	0	0.0	1	6.7	3	18.8	3	21.4	6	16.7	2	22.2	15	16.5
Disagree with *SLSNZ* Removal of Foot Strap	0	0.0	0	0.0	0	0.0	1	7.1	1	2.8	0	0.0	2	2.2
Disagree with *SLSNZ* Regulations - Other	0	0.0	0	0.0	2	12.5	0	0.0	0	0.0	0	0.0	2	2.2
Total Disagree with Regulation Changes	**0**	**0**	**1**	**6.7**	**5**	**31.3**	**4**	**28.6**	**7**	**19.4**	**2**	**22.2**	**19**	**20.9**
Improved Training Necessary	0	0.0	0	0.0	2	12.5	1	7.1	5	13.9	1	11.1	9	9.9
Lack of *SLSNZ* Support	0	0.0	1	6.7	2	12.5	0	0.0	3	8.3	1	11.1	7	7.7
Improved Equipment Needed	1	100	1	6.7	1	6.3	0	0.0	2	5.6	0	0.0	5	5.5
Positive Outcomes of Survey	0	0.0	1	6.7	0	0.0	1	7.1	1	2.8	0	0.0	3	3.3
Unclear on Survey Definition of Injury	0	0.0	0	0.0	1	6.3	1	7.1	1	2.8	1	11.1	4	4.4
Positive Overall	0	0.0	0	0.0	0	0.0	0	0.0	3	8.3	0	0.0	3	3.3
Chronic Injuries[a]	0	0.0	0	0.0	0	0.0	0	0.0	2	5.6	0	0.0	2	2.2
Positive Health Benefits Outweigh Chronic Injuries	0	0.0	0	0.0	0	0.0	0	0.0	1	2.8	0	0.0	1	1.1
Stricter Weather Regulations for IRB*s*	0	0.0	0	0.0	1	6.3	0	0.0	0	0.0	0	0.0	1	1.1
Support of Helmet Regulations	0	0.0	0	0.0	0	0.0	0	0.0	1	2.8	0	0.0	1	1.1
Other	0	0.0	0	0.0	1	6.3	0	0.0	2	5.6	2	22.2	5	5.5
None	0	0.0	11	73.3	3	18.8	7	50.0	8	22.2	2	22.2	31	34.1
Total	**1**	**100**	**15**	**100**	**16**	**100**	**14**	**100**	**36**	**100**	**9**	**100**	**91**	**100**

Not all questionnaire respondents provided feedback. Percentages of totals are taken as the total number of answering respondents (91/196, 46.4%).

a. Chronic injuries were not defined in this questionnaire. Rather, if responses included mention of symptoms or injuries that were 'reoccurring', 'ongoing', ‘persistent’ or the like, they were categorised as 'chronic'.

DISCUSSION

The primary aim of this study was to investigate injuries occurring to surf life savers while operating IRBs in New Zealand. A high rate of lower extremity, soft tissue injuries were reported. However, there was a surprisingly greater incidence of lower back injuries. Risk factors identified include gender and age, with a greater risk of injury for younger females and older males. Landing in the IRB after becoming airborne while navigating the surf were associated with injuries. Furthermore, the repetitive nature of IRB operation may have contributed to the identification of persistent injury symptoms following surf lifesaving participation. To the authors knowledge, this is the only surf lifesaving epidemiological study in New Zealand.

Sequence of Injury Prevention: Epidemiology

The "Sequence of Injury Prevention" was outlined by van Mechelen, Hlobil [1] and is commonly used by researchers. The first step is to identify the extent of the surf lifesaving injury problem through epidemiological studies.

Injury site

SLSNZ hypothesised the increased use of IRBs in New Zealand coincided with an increase in injuries. Previous international research found a high incidence of IRB-related injuries occurring to the lower extremities, particularly the ankle and foot [10, 13, 16]. Similarly, the ankle was consistently one of the most reported injured sites from the questionnaire. This is consistent with Fong, Chan [21], whom identified the ankle as the most commonly injured body site in 24/70 sports. However unexpectedly, the most injuries reported outside the ankle were at the lower back. This is the first study to quantify IRB-related incidences of lower back injuries in the surf lifesaving population.

Injury type

Epidemiological studies in Australia and the United States identified soft tissue injuries as the leading type of surf lifesaving related injuries. The highest severity injuries were fractures and dislocations. Ashton and Grujic [16] investigated 12 lower extremity IRB-related fractures reported to hospitals over 3 years in Queensland; 10 of which required surgical repair. Questionnaire results concurred; most injuries were soft tissue sprains and/or strains. Nevertheless, most soft tissue injuries were to the lower back. Although severity of injury was not assessed in the questionnaire, the potential effects of lower back injuries on long term health may be substantial.

Sequence of injury prevention: risks factors

The second step of the "Sequence of Injury Prevention" was conducted and aimed to identify IRB-related risk factors, establish aetiologies, and understand the mechanisms of injury in order to introduce preventative measures.

Risk factors can be classified as intrinsic or extrinsic [32]. Intrinsic factors identified relating to IRB-operation include gender, age, and experience. Previous literature identified older age as a significant risk factor of injury, yet gender was not significantly related [13, 15]. However, both studies included injuries from all surf lifesaving activities. Furthermore, Mitchell, Brighton [13] demonstrated this relationship only during training, and Jackson [15] reported the relationship as the age at the time of survey completion, rather than the age at time of injury. Nevertheless, results from the questionnaire exhibited similar findings to that of Jackson [15], possibly due to the similar questionnaire lay out. Younger females and older males had a higher incidence of injury, suggesting, surf life savers operating IRBs could benefit from age- and gender- specific injury prevention strategies.

Jackson [15] also identified a relationship between experience and injury, with experienced lifeguards sustaining more injuries over the course of their career. Alternatively, the SLSNZ questionnaire did not find a significant difference between experience level and injury. However, there was a significant relationship between gender and experience level; females made up 46.1% of the beginner questionnaire respondents compared to 18.3% of the experienced respondents. A previously administered survey of 43 surf life savers in Australia revealed inexperience as a main cause of IRB-related injuries [10]. Of the SLSNZ questionnaire respondents, 3/20 beginners reported having driven an IRB without being certified to do so, and 42.5% of beginners preferred driving rather than crewing while on patrol. Furthermore, 47.0% of females preferred crewing on patrol, compared to 60.8% of males who preferred to drive. As crew member position is a recognised injury risk factor [10, 13, 16, 17], this suggests inexperienced and potentially uncertified surf life savers in New Zealand preferring to drive IRBs may explain the increase in injury among younger females with a crewing preference.

Extrinsic risk factors may explain the correlation between crew position and injury risk. Multiple studies have identified an increased risk of injury to surf life savers operating IRBs compared to other surf lifesaving tasks (e.g. nippers, surf ski, etc.) [10, 13] in addition to the recognised impact of IRB equipment on crew member biomechanics [17]. The foot straps inside the IRB were previously found to be directly related to lower extremity injuries [16]. However, equipment related injuries were substantially less common than landing injuries from questionnaire findings. This suggests that a lack of ability to stay within in the boat may be a greater risk factor of injury than the foot strap.

Surf lifesaving is heavily contingent on the weather and water conditions [12]. Other water-based board sports have identified weather conditions as a leading cause of injury. Similar to questionnaire results, kitesurfing, windsurfing, and traditional surfing demonstrated high incidences of lower extremity and lower back soft tissue injuries occurring during airborne landings [24-28]. However, no studies have investigated the effects of weather and water conditions on similar injuries occurring in IRBs. In rescue situations, the weather is uncontrollable, and surf life savers must perform the rescue regardless. Rescues may occur more often in these unfavourable conditions Therefore, future research should examine the effects of weather and water conditions on the mechanisms of lower extremity and lower back injuries during IRB operation.

Ludcke [17] found an interdependency between surf conditions, IRB equipment, and loads (e.g. accelerations) experienced by surf life savers. The increase in landing mechanistic injuries combined with poor weather conditions may demonstrate an inability of the crew members to stay firmly inside the boat without the security of both the left and right foot straps. This is supported by questionnaire findings, identifying the leading cause of injury among 16-20 year olds as ejection from the IRB. Therefore, weather conditions may pose age-specific risk factors causing varying mechanisms of IRB-related injuries. It is possible that the younger surf life savers weigh less and have less strength to assist in keeping them within the IRB. The younger surf life savers may have less experience than older surf life savers. It may be that there are more 16-20 year olds operating IRBs.

Sequence of injury prevention: aetiology and mechanism

Understanding injury mechanisms is a key component of preventing injuries in sports and a full description for each particular injury is necessary. Bahr [33] suggested grouping the injury mechanism into four categories: situation, qualitative description of the athletes' action, description of the whole body biomechanics, and a detailed description of the joint and tissue biomechanics [33]. Researchers have attempted to understand the mechanism of surf lifesaving injuries through computer simulation and pilot quantitative studies [14, 19]. However, these studies are outdated and only reference ankle and foot injuries. Therefore, a full understanding of IRB-related injury mechanisms is necessary to introduce preventative measures.

Situation and behaviour

Mitchell, Brighton [13] and Bigby, McClure [10] reported the most IRB injuries occurred while navigating the surf and negotiating the break. Navigating a wave was one of the main causes of injuries reported in the questionnaire. Nevertheless, landing after being airborne was the lead cause of injury. Moreover, the most reported cause of both lower back and lower extremity injuries was due to landing in the IRB, rather than previously expected equipment related. This is the first study to report this finding among the surf lifesaving population.

Females demonstrate an increased risk of injury during landing behaviors [34]. In agreement, female surf life savers in New Zealand demonstrated a high incidence of landing-related lower extremity and lower back injuries. It may be beneficial to reference female-specific landing literature in other sports in order to gain a better understanding of the mechanisms of injury occurring to female surf life savers.

Whole body and joint biomechanics

The lower extremities may be unable to handle the excessive dynamic loads during landing [27]. Females are predisposed to an increased risk of injury due to poor landing mechanics, demonstrating significantly reduced hip abduction and external rotation isometric strength, as well as side bridge endurance [34]. Weaknesses in these areas may increase female vulnerability to large external forces, and as a result, may be predisposed to excessive motion in the hip or trunk permitting their lower extremity to move into compromised positions [35]. Thus, a complete description of the mechanisms for each joint needs to be developed.

Lower back

Decreased core stability is a known risk factor of lower back pain. A large component of core stability is muscle endurance in the lumbo-pelvic-hip complex. The endurance of the trunk extensors and isometric hip strength has been found to predict the occurrence of lower back pain in 30 - 60 year old adults [35]. Females have demonstrated significantly reduced hip abduction and external rotation isometric strength, as well as side bridge endurance [34]. Weaknesses in core stability may predispose females to lower back pain. Furthermore, the hip muscles help to control rotational alignments of the lower limbs and maintain pelvic stability during a single leg stance [36]. Thus, hip muscle weakness may also contribute to lower back pain due to abnormal segmental movement of the lumbar spine if the pelvis is not stable during operation of the IRB*s*.

According to questionnaire results, 7/15 (46.7%) females over the age of 30 believed surf lifesaving participation motivated them to stay physically fit; compared to only 14/54 (25.9%) females aged 30 years or younger. Furthermore, there was a significant relationship between gender and experience level; females making up 46.1% of the beginner respondents compared to 18.3% of the experienced respondents. The beginners were significantly younger in age, suggesting the younger population may not be physically challenged to the extent of the older female population (e.g. less perceived level of effort). The increase in younger female injury incidences may be due to a lack of core stability, specifically hip strength and endurance.

Ankle

The ankle was consistently one of the most reported injured sites from the questionnaire; the majority being soft tissue sprains or strains. Traumatic ligament sprains of the ankle joint are the most common injuries at every level of sports and comprise about 14% of all sport-related injuries. Among all ligament sprain injuries, roughly 80% are lateral ankle sprains [22]. Although the type of ankle sprain was not determined in this research, the injuries sustained by surf life savers in IRBs are consistent with aetiologies of lateral ankle sprains. Therefore, it may be beneficial to compare IRB-related ankle injuries with mechanisms of lateral ankle sprains common in other sports.

Questionnaire results are consistent with the aetiology of ankle sprain injury; foot positioning during touchdown. When a foot is plantarflexed during touchdown, the contact to the ground is made with the forefoot, increasing the moment arm about the subtalar joint axis and also the resultant joint torque to cause sudden explosive twisting motion and thus, ankle sprain injury [21]. Researchers have demonstrated that people suffering from lumbar fatigue will respond differently to ground reaction forces [37]. In fatigued conditions, such as during repetitive IRB operation, surf life savers may experience less vertical ground reaction forces during landing, due to an adopted “toe-heel” or fore-foot landing approach [38], increasing the risk of an inversion ankle sprain.

The second aetiology of lateral ankle sprain injuries is the delayed peroneal reaction time upon landing [21]. Moreover, reaction time is affected by fatigue. Sudden loads can exacerbate fatigue effects [38], such as that occurring during repetitive navigation of waves in an IRB. Therefore, females operating IRBs are at an increased risk of lateral ankle sprain due to a forefoot landing approach and delayed reaction time, further exacerbated by the impaired reflex latencies due to lumbo-pelvic-hip fatigue.

Other lower extremity

The “toe-heel” landing approach may also explain the increased incidence of injuries to females at other lower extremity joints (e.g. knee, hip). The landing technique results in a “softer” landing as the knee and hip tend to absorb more of the ground reaction forces. Females have demonstrated lower hip abduction and increased knee valgus when landing from a jump [34]. Medial collapse of the lower extremity during weight-bearing activity, described as adduction and internal rotation of the femur accompanied by knee valgus, tibia internal rotation, and increased foot pronation, might be related to hip-strength imbalance in the frontal plane [30]. Studies have shown that reduced isometric strength of the hip abductors relative to the hip adductors is associated with increased pronation at the foot. Correlations between hip abductor strength and landing kinematics were found to be larger for females than males, suggesting hip abductor strength may play a more important role in the neuromuscular control of the knee for females [34]. Female surf life savers may be at an increased risk of acute knee injury [34] during IRB operation due to a lack of hip (trunk) strength.

Chronic injuries

The activity of superficial trunk muscles is impaired in patients with lower back pain during dynamic tasks over unstable surfaces [39]. The hip (trunk) muscles are tightly coupled with the lumbar paraspinal muscles via the thoracolumbar fascia, which allows the load transfer from the lumbar spine to the lower extremities [36]. The high number of lower back injuries sustained by surf life savers may be closely related to the high number of ankle and other lower extremity injuries. Research has shown the single best predictor of future lower back pain is a history of lower back pain [40]. Chronic lower back pain may affect landing techniques in fatigued states, therefore increasing the possibility of ankle and other lower extremity injuries. Thus, the different types of injuries seen in surf life savers may be related in nature.

This theory is consistent with questionnaire findings, as over 75% of respondents reporting chronic injuries had sustained a lower extremity injury during patrol utilising an IRB. Furthermore, questionnaire results identified ankle and soft tissue injuries as the most “repeat” injuries. Literature has shown that 74% of patients whom suffered from an inversion ankle sprain injury had persisting symptoms 1.5 - 4 years after, in which 10 - 30% may have had chronic symptoms, such as persistent synovitis or tendinitis, muscle weakness, and frequent giving-way [21]. This suggests an increased risk of developing persistent injury symptoms due to IRB operation.

Sequence of injury prevention: prevention strategies

To address the potential effectiveness of injury prevention strategies, injury mechanisms must be considered in relation to intrinsic and extrinsic risk factors. Younger females seem to be at an increased risk of IRB-related injury due to do a lack of trunk strength. Although no strength interventions have been assessed for effectiveness in surf life savers, researchers in other athletic populations have recommended female athletes focus on improving proper landing technique, as well as core and hip strength [27]. Therefore, surf life savers operating IRBs could benefit from age- and gender- specific strength training interventions to increase hip and trunk musculature strength and endurance.

Equipment related risk factors may also be modifiable in order to reduce injury occurrence. Biomechanical limitations have been shown to be highly variable and dependent on the crew member foot strap positions and angles [17]. Furthermore, female questionnaire respondents were found to be relatively shorter than their male counterparts. Female anthropometrics may place crew members in a biomechanically disadvantageous position. Therefore, modifications to IRB equipment to accommodate gender-specific anthropometrics may reduce the incidence of female surf lifesaving injuries.

With recent IRB regulation changes, and recognised impact of equipment on IRB operation and crew member biomechanics [17], future studies should focus on identifying current equipment standards of clubs in New Zealand.

Limitations

The main finding of this study was the likely high incidence of chronic lower back and lower extremity injuries. However, incidences of chronic injuries are difficult to determine. All questionnaire respondents reporting chronic injuries had sustained an injury during competition, however, none of the injuries were reported to SLSNZ. Furthermore, respondents did not report their injuries because they were not severe enough or symptoms did not develop until later. The nature of chronic injuries; occurring over a period due to repetitive movements, with no identifiable inciting event, likely adds to the underestimation of injury and long-term impact of surf lifesaving participation.

Results indicated that there is an underestimation of injuries due to low reporting rates. Less than 1/3 of respondents reported all their patrol injuries to SLSNZ, and less than 1/9 reported all their competition injuries. Interestingly, only one female respondent reported all competition injuries (1/24). Reasons for reporting varied, yet 64.7% were unaware of the SLSNZ reporting regulations and procedures (not severe enough, occurring at training, at fault, unaware of procedures, lack of supervisory guidance); thus, demonstrating a need for improved member training and upskilling of supervisors.

Injury results from the questionnaire should be taken lightly for several reasons including participation bias, lack of injury definition understanding, and questionnaire arrangement. The main limitations are methodological; primarily, the validity and accuracy of self-reported injuries. Results rely upon respondents’ memory in order to describe any and all injuries sustained. Furthermore, many respondents had greater than 10 years of surf lifesaving experience; thus, it may have been difficult for respondents to remember all injuries sustained and details surrounding the occurrences.

Confusion surrounding the definition of injury is also a limitation, as some respondents may not have reported training-related injuries. Questionnaire results did not provide age at the time of injury, and therefore, injury incidence rates based on population data could not be calculated. Furthermore, due to the set-up of the questionnaire, mechanisms of injury were only available for one injury per anatomical location; restricting further analysis of repeat injuries. These limitations may have resulted in an underestimation of injury occurrence. Consequently, the focus of questionnaire results was placed on participant feedback, demographics, and overall injury frequencies.

All injuries (self-diagnosed or health care) were accepted and were not deciphered by the respondents.

Future recommendations

Future surf lifesaving research should focus on quantifying the occurrence of chronic lower extremity and back injuries sustained during operation of IRBs by surf life savers in New Zealand. Furthermore, future research should assess the physical fitness level of surf life savers in New Zealand. Specifically, current IRB crew member guidelines and strength requirements should be considered in order to assure crew members are able to stay inside the IRB and withstand the loads experienced during operation. Preventative strategies such as age- and gender- specific strength training, warm-up protocols, and equipment changes should be implemented and investigated to determine effectiveness in reducing the occurrence of acute and chronic soft tissue injuries.

CONCLUSIONS

The occurrence of IRB ankle, lower back, and chronic injuries (15.6% of respondents) and lack of reporting should be addressed by Surf Life Saving New Zealand. Injury prevention strategies should focus on strength training, technique modifications, and equipment design changes should be applied to 16 to 30 year olds, and females. Further research is warranted to assess the effectiveness of injury prevention strategies and injury reporting methods.

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